

1 **METHOD OF IDENTIFYING FLUID PURIFICATION EQUIPMENT WHICH**
2 **IS OPTIMIZED FOR INDIVIDUAL FLUID PURIFICATION SYSTEMS**

3
4 **BACKGROUND OF THE INVENTION**

5 *Field of the Invention:*

6 The invention herein relates to equipment used for fluid (i.e., gas, liquid
7 or mixed gas and liquid) purification. More specifically it relates to methods for
8 identifying such equipment which is optimal for use in an particular fluid
9 purification system.

10 *Description of the Prior Art:*

11 There are many processes in industry which involve fluid purification.
12 These include processes in which reactant materials are deposited from fluid
13 streams and processes in which fluids are used to remove impurities from
14 surfaces of materials. The degree of purity which is necessary for a particular
15 fluid stream will depend upon the use to which the fluid stream is to be put, but
16 in many cases it is necessary to purify the fluid to a level at which the
17 contaminant concentration in the fluid is at the parts per million (ppm) or parts
18 per billion (ppb) level.

19 There are numerous types of fluid purification equipment available in the
20 marketplace. However, notwithstanding the different types of equipment
21 available, operators of fluid purification processes often find that the selection of
22 available commercial "off the shelf" devices does not provide a device which is
23 particularly suitable for the unique nature of an operator's particular process.
24 Consequently in the past operators of fluid purification processes have often
25 been faced with the choice of using a market-priced, commercial piece of
26 equipment which may be acceptable but is not ideal for the process or of having
27 to have an expensive custom piece of equipment designed specifically for the
28 process.

29 Those prior art pieces of equipment were originally available for selection
30 through catalogs. The process operator examined catalogs from several
31 vendors and selected the piece of commercial equipment that came closest to
32 what would be useful in the his or her process. The vendor's sales personnel

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1 might be available to assist with the operator's selection, but the end result was
2 still selection of a standard piece of equipment, with little or no accommodation
3 to the operator's particular process. With the advent of the Internet, vendors
4 have in effect been able to put their catalogs online, so that operator using the
5 Internet can select an available piece of fluid purification equipment at the price
6 that the operator is willing to pay. The Internet has also allowed vendors to
7 replace the indexing system of typical catalog with a data input system which
8 allows the operator to enter representative parameters of his or her process and
9 then the vendor's software identifies the closest commercial product available
10 from that vendor. Such systems, however, whether in printed catalogs or on the
11 Internet are still at the level of end products. The operator must therefore
12 determine which properties of the end product he or she is willing to compromise
13 on to obtain other components which are closer to optimal for the process of
14 interest. An operator who is faced with only a limited number of available
15 commercial products may have no choice but to accept equipment with, for
16 instance, poor corrosion resistance in order to obtain, for instance, the desired
17 range of fluid flow rates through the equipment. This is a result of the lack of
18 prior art methods and software which would allow an operator specify or obtain
19 a device which would be optimum for the particular fluid purification process in
20 question on a component-by-component basis.

21 Another current problem for operators is that effectively they can only
22 access information and order equipment during the regular working day, since
23 they must normally interact directly with vendors' personnel to obtain quotes,
24 discuss product selection, etc. Even where the operator has a vendor's
25 catalogue, they can do little more than get a preliminary idea of what they might
26 need from the catalogue, and must still work directly with the vendor's personnel
27 to develop the full equipment and cost package. This is a particular problem if
28 a vendor is located in a different time zone from the operator. Of course this
29 also means that vendors must maintain substantial staffs of personnel to work
30 with the operators to develop such packages, since the catalogues alone do not
31 enable operators to determine for themselves what equipment is appropriate for

1 their systems, and the catalogues certainly do not allow an operator to custom
2 design a system specifically to meet his or her needs.

3 It would therefore be advantageous if a method were available through
4 which a fluid purification process operator could specify in detail the applicable
5 parameters of his or her process and which would then result in specification of
6 components which when assembled would be specifically adapted to be used
7 in the operator's process in an optimal manner. It would also be advantageous
8 for that system to be fully available to an operator at all times.

9 10 **SUMMARY OF THE INVENTION**

11 The present invention overcomes the limitations of the prior art by
12 presenting to an operator of a fluid purification system an interactive method by
13 which the operator can identify the significant parameters of his or her system
14 and the method of the present invention will identify for the operator a
15 component-level-based fluid purification equipment package which will be
16 optimized at the component level to the operator's specific requirements. The
17 operator is thus enabled to identify that combination of components which, when
18 assembled, can be operated in a manner to provide, in his or her system, optimal
19 fluid purification, taking into account many variables including fluid type, flow
20 rate, contaminant challenge, and required output fluid purity. For the purposes
21 of this invention, "fluid" will include any one or more of gases, liquids, mixtures
22 of each and mixtures of gases and liquids together. "Gases" also includes
23 "vapors." "Purification" includes fluid filtration and liquid or gas regeneration
24 systems. The fluid purification or decontamination processes to which the
25 invention is applicable can be those which reduce contamination to any degree,
26 including those where contaminant reduction levels are down to the parts per
27 million or parts per billion ranges.

28 For brevity herein, the invention will often be exemplified in the discussion
29 below as a gas purification system. It will be understood, however, that unless
30 the context indicates otherwise, the discussion is equally applicable to
31 determination of components for liquid and liquid/gas purification systems.

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1 The central aspect of the invention is a relational database containing data
2 on all pertinent aspects of fluid purification equipment and the components
3 thereof, and associated operational software to which the operator gains access
4 through a computer and which then presents to the operator a series of
5 questions relevant to fluid purification equipment and system requirements. The
6 content and order of presentation of the questions is such that the answers
7 elicited from the operator for each question determine what the successive
8 questions will be. At each level of question the system of this invention uses the
9 operator's answers to identify appropriate portions of the database and identifies
10 and selects data from those portions directly related to the operator's indicated
11 requirements and/or identified the next successive path segments through the
12 interactive sequence of questions most applicable to the operator's indicated
13 requirements.

14 The net result is that, at the end of the sequence of questions and
15 answers, the method of the invention generates from the optimized components
16 identified and selected, a complete fluid purification equipment package for the
17 operator's consideration, which is optimized specifically for the operator's
18 particular system requirements. Since the owner and provider of the method,
19 database and software of the invention will normally also be a vendor of fluid
20 purification equipment, the system operator will also usually be able to purchase
21 the designated equipment from the vendor at the conclusion of the operator's
22 use of the method of the invention.

23 The operator is thus able to determine, quickly and easily, and with the
24 most current data, what equipment will best suit the requirements of his or her
25 fluid purification system, and also to obtain such equipment, customized to those
26 requirements at the equipment component level. The operator will therefore no
27 longer be required to accept predesigned equipment which, while perhaps
28 having a few optimal aspects, will also have other aspects which are not only not
29 optimal, but which may in fact be detrimental to overall optimal system
30 performance. Additionally, the vendor does not need to maintain large personnel
31 staffs, since the operators themselves can optimize their own packages and

1 place their own orders, and can do so at any convenient time and wherever they
2 may be. It also allows operators to consider and compare all available
3 components and combinations, from distant as well as local vendors.

4 Therefore, in a principal embodiment the invention herein involves a
5 method for identifying fluid purification equipment which is optimized for use in
6 a particular fluid purification system, which comprises providing a database of
7 specifications regarding a plurality of equipment components from which
8 selection of individual components may be made; providing access to the
9 database through an interactive interface of an operating system comprising a
10 series of sequential inquiries, response to each of which determines a next
11 inquiry to be posed or a component to be specified, the inquiries eliciting defining
12 information regarding the particular fluid purification system; and using the
13 defining information to identify those of the components which, when assembled
14 to form the fluid purification equipment in a manner specific to the particular fluid
15 purification system, can be operated so as to optimize fluid purification in the
16 particular fluid purification system.

17 In another principal embodiment, the invention involves apparatus
18 comprising electronic media for identifying fluid purification equipment which is
19 optimized for use in a particular fluid purification system. The media provides a
20 database of specifications regarding a plurality of equipment components from
21 which selection of individual components may be made. Access to the database
22 through an interactive interface of an operating system comprising a series of
23 sequential inquiries, response to each of which determines a next inquiry to be
24 posed or a component to be specified, with the inquiries eliciting defining
25 information regarding the particular fluid purification system. The defining
26 information is used to identify those of the components which, when assembled
27 to form the fluid purification equipment in a manner specific to the particular fluid
28 purification system, can be operated so as to optimize fluid purification in the
29 particular fluid purification system.

30 Other embodiments and aspects will be evident from the detailed
31 description below.

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1 halogen gases or strong liquid acids or alkalis; and fluids which have other
2 properties which require special attention, including oxidizing gases such as
3 oxygen and flammable or explosive gases such as hydrogen or light gaseous
4 and liquid hydrocarbons. It will be evident of course that the different types of
5 fluids commonly require different types of fluid purification equipment, and it is
6 a principal characteristic of this invention that its use allows an operator to
7 prescribe and obtain equipment optimal for use with the particular fluid at issue,
8 no matter whether its properties are benign or aggressive.

9 Similarly, the present invention is applicable to fluid purification systems
10 regardless of what type of fluid impurity or contaminant is present in the system.
11 The invention can accommodate and specify a particulate filtration component
12 as well as a component that separates entrained liquids from a gas stream or
13 dissolved or dispersed gases from a liquid stream, and also components such
14 as adsorbents which separate gaseous contaminants from a main gas stream.

15 Central to the present invention is an overall relational database which
16 contains all of the relevant information on the various components which can be
17 part of a fluid purification system, along with information regarding the
18 interconnection of these various components. This database will contain
19 information, for instance, regarding all of the applicable gas adsorbents which
20 can be used to separate gaseous contaminants from a main gas stream, various
21 gas/liquid separation devices to separate gases from a target liquid or vice
22 versa, various materials from which the equipment can be manufactured and the
23 various fluids which an operator may wish to purify. Similarly, the database will
24 contain information regarding various types of pipe and tubing fittings, applicable
25 flow rate data and flow resistance data. Because of the relational nature of the
26 database, the various data included can be interrelated to each other based on
27 the fluid purification equipment requirements defined by the operator/user of the
28 database during the interactive question/answer performance of the invention.

29 The database will also preferably include data on the operational context
30 of the fluid purification system. This will permit the system to offer to the
31 operator the ability to include in the selection criteria ancillary equipment to be

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The invention accomplishes this objective by applying to the database a software inquiry system which poses a series of predetermined questions to an operator regarding his or her gas purification requirements and from the step-by-step answers elicited from the operator selects the various components which when combined will be optimized gas purification equipment for the operator's specific process. The operator is therefore able to obtain gas purification equipment which is optimized at the component level rather than being forced to choose between vendors' end products, each of which is likely to have only a few, and definitely not all, of its components optimized for the operator's own particular gas purification requirements.

There are a number of different relational database software programs available commercially which are capable of presenting a user (i.e., the operator) with a series of structured, predetermined questions and a list of acceptable answers for each question, and from the answer selected by the user for each

question be able to search the database and select information (i.e., in this case component identification) which are most responsive to the user's answers. The specific descriptions and details of such software therefore do not need to be described in detail in this specification. In any event it will be the owner of the database which provides the software and the software itself will be essentially transparent to the user. The user, having logged on to the software/database system of the present invention, will simply encounter a series of interactive screens or Web site pages which pose the applicable questions seriatim and use the answers individually or in combination to retrieve from the database identification of the components which, when combined, will result in the specification of gas purification equipment which will provide overall optimum performance in the system specified by the operator in response to the interactive questions from the software.

The method of the present invention can then be understood best reference to the Figure of the drawing. The Figure illustrates the first three steps and the final results in a typical operator/user interaction with the software and database by which the present invention identifies optimized gas recovery equipment for the invention user. Starting first at the top of the diagram of the Figure, the operator after having logged into the system through his or her computer 40 (either by the Internet 41 or through hard media 42 such as a CD) is presented with a first question 1 as indicated at 43. The question 1 will be accompanied on the computer 40 through the Internet interface 41 or CD 42 with a list of acceptable answers, and the operator/user will be required to indicate his or her answer 1a from that list of answers. Once the answer 1a is elicited and transmitted by to the system, also as indicated at 43, the software initiates a step-by-step search through the database to identify one or more portions of the database relevant to that answer and identify information (e.g., individual component information and specifications) which is most responsive to the answer 1a selected. The Figure illustrates how the difference acceptable answers 1a to question 1 lead to separate paths 14, 15, 16, ... in which are performed searches of different portions 10, 11, 12, ... (13)... of the database.

1 Each of these portions of information may be considered to be "subdatabases"
2 of the main database. Each of the various answers 1a to the question 1 will lead
3 to one of the subdatabases 10, 11, etc. For example, in many cases the first
4 question to be posed to the operator/user by present method will be to identify
5 the specific gas which is to be purified. Specification of a noble gas such as
6 argon may, for example, start the process down one path 14, whereas if the
7 answer 1a identified a corrosive gas, that could start the process down a second
8 path 15 or 16, and so forth. Different selections of answers to a question may
9 also lead to the same path; for instance, if acceptable selections from the list of
10 answers 1a include argon, neon, or helium, all may lead to path 14 since all are
11 noble gases.

12 Regardless of which path ends up being selected by the answer 1a, a
13 result of accessing the subdatabases 10, 11, etc. may be a search that will
14 identify a particular designation of information 10', 12', Designation of
15 information such as 10' may be of a specific component of gas purification
16 equipment, a specific type of material to be used for the equipment, or any other
17 information which is responsive to the answer 1a elicited from the operator. It
18 is also contemplated that in some cases the designation of information 10', ...
19 may be negative information, in that for example it may be identification of
20 equipment, materials, or the like which will not be suitable in the operator's
21 system, and which will thereafter be excluded from consideration (e.g., inclusion
22 in answer lists) by the system. Alternatively, as with subdatabase 11, the
23 response generated by the answer 1a may simply be to identify the start of the
24 path 15, and that the access to subdatabase 11 is intended not to generate a
25 search at this level but rather to begin the focus of the method on a final
26 selection of gas purification equipment which will be defined in part by the
27 parameters of subdatabase 11.

28 The method of the present invention, having completed the first step, then
29 moves to a second level and presents the operator/user with a second question
30 2a, 2b, Because the question posed at level 2 is dependent upon the
31 subdatabase 10, 11, etc. to which the software was directed by the answer 1a

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at level 1 of the questions, questions 2a and 2b will not necessarily be the same question, and in fact may be quite different questions. Even if questions 2a and 2b are the same question, the list of acceptable answers that each presents to the operator may be the same, may be entirely different, or may have some of the same answers and some different answers. For instance, if as in the example mentioned above the question 1 on identification of a specific gas led to an "inert gas" path 14 or a "corrosive gas" path 15, and the second question 2 called for identification of a specific material from which applicable gas purification equipment might be made, the list of acceptable answers 2a would be expected to be longer than the list of acceptable answers 2b, although many if not all of the answers in the list 2b would also be on the list 2a, but not vice versa.

The system then proceeds as described above respect to a second level of subdatabases 20, 21, 22,... (23).... In the Figure in this level is also illustrated as having subdatabase 21 made up of two portions 21' and 21". The Figure at this level also illustrates that the particular response 2a may lead to any of the subdatabases 20, 21', or 21", while a response 2b may lead to subdatabases 21" or 22. At each level, as illustrated for this level 2, the step may include a subdatabase search such as at 20 which leads to identification of information 20', ... , or merely to identification of the parameters of the particular level 2 subdatabase, as was described above with respect to subdatabase 11. (The specific responses or searches therefore need not be specifically shown for the other subdatabases 21 and 22.)

Thereafter the system moves on to pose questions at level 3 as indicated at 3A, 3B, 3C and 3D, each of which elicits respective answers 3a, 3b, 3c or 3d. Illustrated in the figure at this level is that two different subdatabases (here illustrated as 21" and 22) may lead to the same question at the next level. Also illustrated this level is that the next question following a particular subdatabase such as 12 does not necessarily occur at next level, but may skip levels as indicated at question 3D and answer 3d. For instance, if the path 16 from question 1 were defined for explosive gases, and the second level of questions

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1 did not relate to explosion hazards, the system would bypass that level for path
2 16 and go directly to the third level (or wherever the next level with a relevant
3 question occurred).

4 It is also contemplated that the system may include provisions which allow
5 for custom design of specific components. For instance, an inquiry could be
6 designed to offer choices of several vendor-specified embodiments of a
7 particular component and also a choice of an operator-specified embodiment.
8 If the operator responded that he or she wanted to specify the properties of the
9 component, the system could list the various component parameters from which
10 the operator could select an unique specification. The system could then
11 determine if the combination specified by the operator was feasible (e.g., that the
12 operator had not specified incompatible parameters), and if so, formulate a quote
13 of the cost for the vendor to produce the custom component. The operator could
14 then confirm or cancel the request.

15 Similarly, the method of the invention includes a compatibility function in
16 the software to analyze responses to the inquiries and to present notice to the
17 operator when a series of responses results in possible selection of incompatible
18 components. While for the most part the software anticipates and avoids such
19 results, by using the responses to earlier questions to determine what response
20 choices are made available for subsequent questions, not all responses or
21 results can be anticipated in advance. Therefore when an incompatibility is
22 identified by the software, the operator will be notified by an on-screen warning,
23 and will be requested to respecify the affected components or elements thereof.
24 If desired, the software can allow be designed to present to the operator one or
25 more alternative choices which would avoid the incompatibility.

26 Ultimately through a series of additional questions and answers as
27 exemplified by the extended path 14 (identified by the wide line in the Figure),
28 enough information has been determined from the operator's answers to the
29 questions that the relational system can present the operator with at least one
30 fully compiled and interrelated package of information 10', 20', etc. which defines
31 a fluid purification equipment system 100 which is optimized for the operator's

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1 process. It will be recognized that optimization is a function of numerous factors,
2 including technical, environmental and economic factors. Thus an operator may
3 actually consider that there can be several possible "optimum" fluid purification
4 systems for the operator's specific needs, depending on the weight given to the
5 different factors. The present invention therefore includes the function that the
6 inquiries and operator's responses can generate more than one such package,
7 when the database operational software identifies components that fit the
8 operator's needs but differ in their technology or economics. For instance, if the
9 operator specifies that purification of the fluid down to a 1 ppm contaminant level
10 is acceptable, the system may generate two possible component combinations,
11 both of which meet this criterion, but where one has higher cost but greater
12 contaminant reduction than the other, and the operator can then choose
13 between them. Thus, as exemplified in the drawing, the system through 14' and
14 14" could generate alternative component combinations 101 and 102, in addition
15 to combination 100, so that the operator could choose among them based on his
16 or her choice of what functions or features should be given greater weight. For
17 instance, using the above example, one operator might decide that the higher
18 cost system was optimum since it allowed for a wider range of product
19 contaminant loads while another operator faced with the same choice might
20 decide that the other combination was optimum since it performed adequately
21 at lower cost.

22 Similarly, other paths through the system, as defined by other answers
23 given at various levels by other operators, will lead to other gas purification
24 equipment systems 103, 104 and so forth, which are optimized for those
25 operator's requirements based on their unique inputs of information.

26 It will be understood that the Figure is diagrammatic and that in any given
27 embodiment of the present invention the sequence of questions, the lists of
28 acceptable answers, and the particular relational software-derived paths may be
29 different. While as indicated, a specific question presented at one level will be
30 dependent upon the answers given at previous levels, which in turn have defined
31 the particular path leading to the level of the specific question, in many cases a

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1 sequence of questions may be presented as a matter of convenience rather than
2 necessity. For example, a question related to operating conditions such as gas
3 temperature or pressure may precede or follow a question related to the
4 identification of the gas itself. Specific questions may cause paths to diverge as
5 indicated following question 2B and subsequently converge as indicated at
6 question 3C, since in many cases two or more questions and answers are
7 needed to fully identify a component and the order in which the relevant
8 parameters are established is not important. It will also be understood that the
9 diagramed Figure does not necessarily represent a particular algorithm used by
10 a particular software program which is being used to search the database. It is
11 not necessary that software be structured in the form of "levels" but rather may
12 use well-known computer architecture techniques such as sequences of
13 subroutines to schedule and present questions and to act upon answers. It will
14 be recognized that the invention resides in the concept of integrating a series of
15 interactive questions and answers with related database and/or subdatabase
16 searches which allow optimization of the gas recovery equipment selection on
17 a component basis rather than simply directing an operator/user to a
18 non-optimized product of predetermined design.

19 The media through which the method of the present invention is
20 presented to the operator for use may be any appropriate electronic medium,
21 including but not limited to hard media 42 such as the computer 40's internal
22 memory hard drive or interactive CD-ROMs or DVD-ROMs accessed through
23 readers therefor integrated into the computer 40 or access through the global
24 interactive computer network 41 (i.e., the Internet). It is contemplated that the
25 latter, the Internet and associated Web site(s), will be the preferred medium of
26 presentation. Selection of gas purification equipment is for most process
27 operations not a frequent event, and therefore most are reluctant to invest in
28 hard media which may be used only once in a number of years, and in which
29 some of the included data may become obsolete during the long intervals
30 between use. Therefore is it anticipated that most operators will want to access
31 the Internet Web site or sites which present the method of this invention. Such

The system can be operated on many different kinds of computers, including but not limited to desktop computers, laptop computers and Internet-access-specific computers. Especially for vendors' field representatives and system operators who are themselves frequently away from their offices, it is desirable to use laptop computers and to have the databases and operating software on CD's or DVDs or maintained on the computer's hard drive, so that the system may be accessed and used at any time and in any locale. Of course, having the system accessible over the Internet also makes it available at any time of day or night and at any locale where Internet access is available. Since many computers are now equipped for wireless access to the Internet, availability of the system is extensive. In either case the operator is no longer

1 limited to obtaining information or making selections only during a vendor's
2 working hours, and a representative is not limited to meeting with customers only
3 when directly access to a home office for information is possible. Further, the
4 Internet information can be updated immediately upon any changes in
5 component availability, cost, features, etc., so that one accessing the system
6 over the Internet has the most current information. Provision can also be made
7 for operators and representatives to download updates to their own computers
8 and incorporate the new information directly into the program copies in their
9 computers' memories or to supplement previously received CDs or DVDs. CDs
10 and DVDs can also be updated on a frequent schedule and distributed, in a
11 manner which provides much more currency of the information than has
12 previously been available from vendors' catalogues, since catalogues require
13 much more time and expense to update, reprint and distribute.

14 It will be evident that there are numerous embodiments of the present
15 invention which are not expressly described above, but which are clearly within
16 the scope and spirit of the invention. The above description is therefore to be
17 considered exemplary only, and the actual scope of the invention is to be defined
18 solely by the appended claims.

19 I CLAIM:

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